UNIVERSITY OF AGDER

Mathematical Modelling and Mathematical Competencies: The Case of Biology Students

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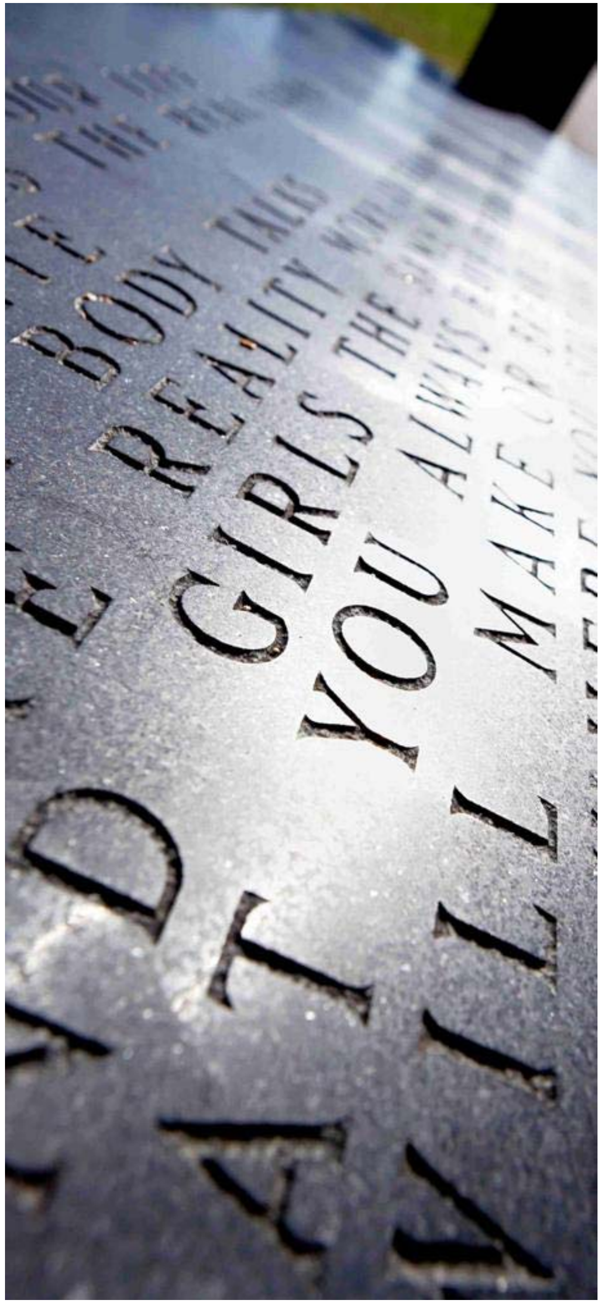


The study

- number of interventions in a standard freshmen mathematics course for biology students
- introducing mathematical modelling tasks
- engage students more actively into learning mathematics through modelling tasks that are biologically ‘colored’
- individual progression (if there is any) of students’ mathematical competencies during the sequence of modelling sessions

State Of The Art

- learning benefits associated with engaging students in mathematical modeling
- many researchers found an analytical tool for identifying competencies involved in modelling (Kaiser et al., 2006)
- students engaged in modeling may develop a deep understanding of the content and an ability to solve novel problems (e.g. Wynne et al. 2001, Lehrer & Schauble 2005)
- other studies (Schwarz & White 2005; Windschitl et al. 2008) have shown that modeling curricula can bring students into alignment with the epistemic aims of science and help them develop more sophisticated ideas about the scientific enterprise as a whole
- Sriraman et al. (2009) blended the notion of interdisciplinarity with modelling highlighting the necessity for creativity and giftedness across disciplines

Two Assumptions

- modeling has the potential to sharpen students’ mathematical competencies
- supports meaningful reform efforts in scientific education

Main Research Questions

- Can mathematical modelling assist a student to develop mathematical competencies?
- What is the dynamic competence profile of the students involved?

What is 'competence' ?

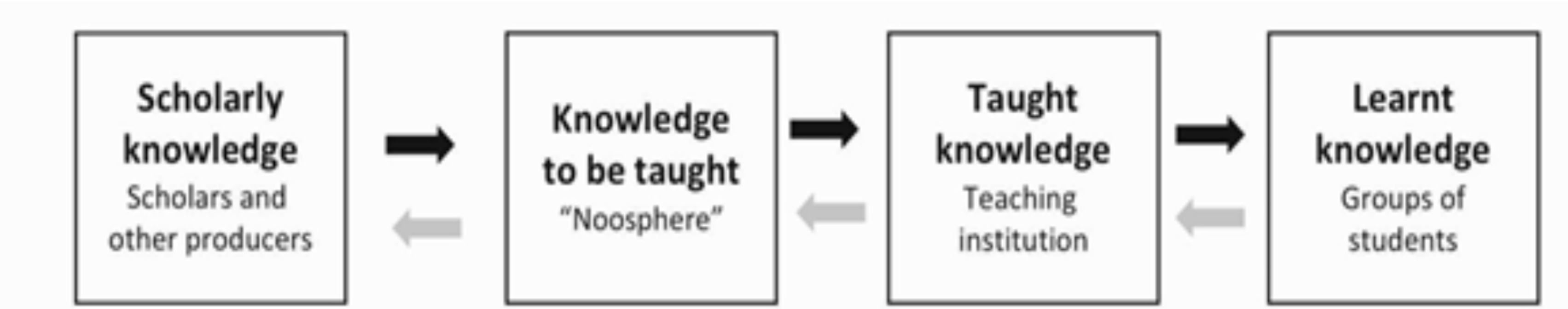
- the sum of the student's available and learnable abilities and skills, the willingness of a student to solve upcoming problems and to act responsibly and critically concerning the solving of a problematic situation (task). Weinert (2001)

- Niss (2003) focused more on the notion of 'mathematical competence' and described it as an individual's ability to use mathematical concepts in a variety of situations, within and outside of the normal realm of mathematics

- the insightful readiness to act in response to the challenges of a given situation. Blomhøj and Jensen (2007)

A Theoretical Framework

- theory of didactical transposition
- Guy Brousseau’s theory of didactical situations (TDS)
- Yves Chevallard’s Anthropological Theory of Didactics (ATD)

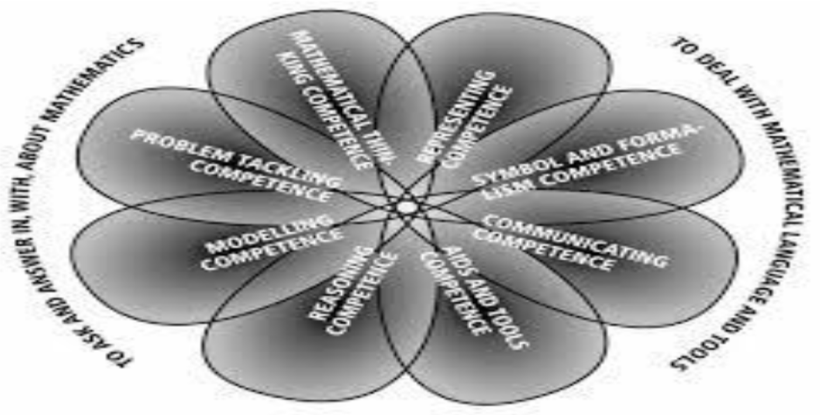


Research paradigm

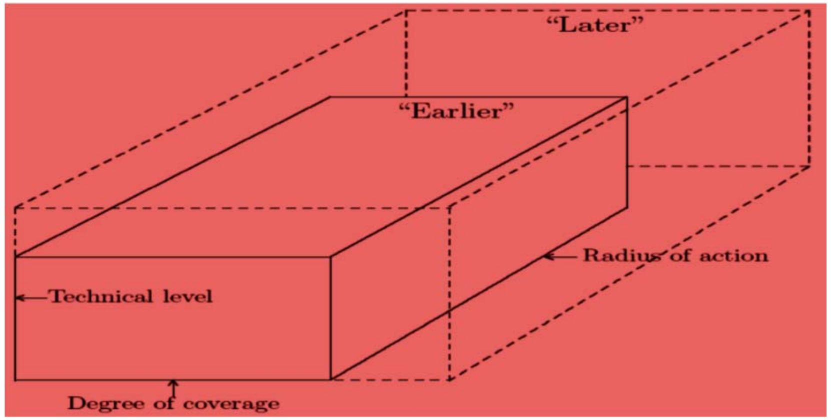
- post-positivistic approach
- survey research
- qualitative methods such as interviews and participant-observation (Creswell, 2009)
- interact with the students in many phases which consists an integral element of the post-positivism paradigm

Cutting Edge

- The KOM project (Niss, 2003) focused on basing the description of mathematics curricula primarily on the notion of 'mathematical competence'



- Niss and Højgaard (2011) combined assessment and competence 3D model



Understanding the … Understanding

- Mathematical understanding is a fuzzy and vague process and by 'breaking it down' in smaller concrete pieces (mathematical competencies) I may be able to locate and identify the process of students' thinking in respect to the undertaken didactical approach
- attempts towards this direction from Andersen et al. (2001) and OECD (1999, 2001) focusing on the PISA investigations
- international comparison of students' competence profiles for the age of 15 but not at the tertiary level
- it would be worthwhile to investigate this possible combination for university students

- "Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgements and to engage in mathematics, in ways that meet the needs of that individual's current and future life as a constructive, concerned and reflective citizen" (OECD, 1999, p. 41)

- mathematical competence as something that students must bring into action in order to meet the challenges of the future
- strong connection to what Blum et al. (2002) considered as vital elements of modelling competences
- competent student: able to structure, mathematize and solve problems
- knowledge alone is not sufficient for a student to develop his/her mathematical competencies
- a student has to use and direct his knowledge with a suitable and specific way in order to be successful in modelling
- this is where my study focuses on: observing, monitoring and analyzing that process

Object of Study

<u>monitor individual's progression of competence</u>

I. Identifying the existing set of student's competencies

II. Estimation of student's competence depth (level) based on the three-dimensional framework

III. Progression (if there is any) of levels of mathematical competence during the study

IV. Final estimation

- The two first steps will be analyzed be the three-dimensional scheme and a coding system by the end of the second session. Steps III and IV will be studied and analyzed by the completion of the whole project (8-10 sessions)

Research Strategy

- mixed-method strategy
- qualitative and quantitative approaches
- coding system has qualitative characteristics that could be analyzed with quantitative methods

Research Design

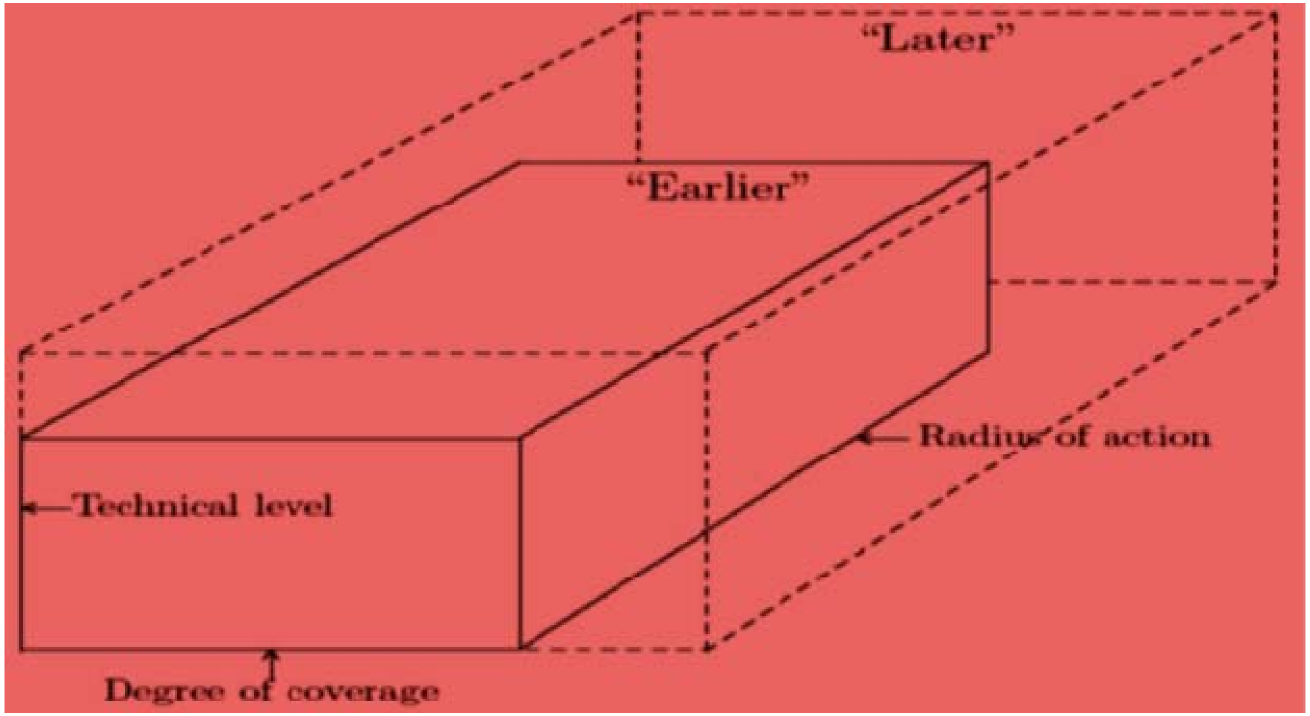
- 8-10 modelling sessions
- three separate groups of 3 to 4 students
- tasks will be chosen and formed based on the notion of mathematical competencies
- I expect that students will feel the necessity to activate a set of different mathematical competencies
- interview with the task designer will take place before and after every two sessions with the students in order to obtain a clear image of what knowledge is planned to be taught, what knowledge was actually taught and finally what knowledge was learnt

The Tasks

- Niss and Højgaard (2011) argue that mathematical activities in form of tasks should act in a different way than just looking into the content of a competency from a theoretically and empirically perspective
- "…partly to find a way of evaluating the individual person's mastery of a given mathematical competency, and partly to get an overall picture of the respective person's mathematical competency profile"
- valid and reliable tasks in order to obtain a clear method to identify the presence of a certain mathematical competence
- design the tasks in such a manner that my coding system will function in an operative and resultant way
- cover the bigger part of the mathematical competencies spectrum

Methods for Data Generation

- students’ written work (tasks and assignments)
- recordings (video and audio)
- hand notes
- selected groups will be provided with a special device (LiveScribe 3 smartpen) for more accurate and faster data collection


"Later"
"Earlier"
Radius of action
Technical level
Degree of coverage

The Three Dimensional Model

- Technical Level: indicates how and to what degree (how advanced) a student may use his/her tools and mathematical entities which belong to his/her cognitive set of knowledge in order to activate a certain competence

- Radius of Action: illustrates the range of action a student may take in terms of context and didactical situations. It shows where a student can activate a specific competence

- Degree of Coverage: indicates to what extent a student is developing a competence in terms of its specific characteristics

A Decoding Example

The reasoning competence ‘broken down in discourse pieces’

- When a student is able to follow and assess a chain of arguments. Code: Flw. Arg.

- Knowing the difference between a formal mathematical proof and other kinds of mathematical reasoning. Code: Pr. ≠ Math. R.

- Separating main lines from details and ideas from technicalities during a line of arguments posed by anyone in the classroom. Code: Sep.

- When a student has the skill to devise formal and informal mathematical arguments. This may differ from a typical mathematical proof in our study therefore we could include the term: proving statements. Code: Pr. St.

Claims for Knowledge

- My study will be considered successful if I we will be able to determine if there has been a progression in students' level of competence

- additional argument in the discussion about the beneficial impact of mathematical modelling in tertiary education

Thank you for not falling asleep